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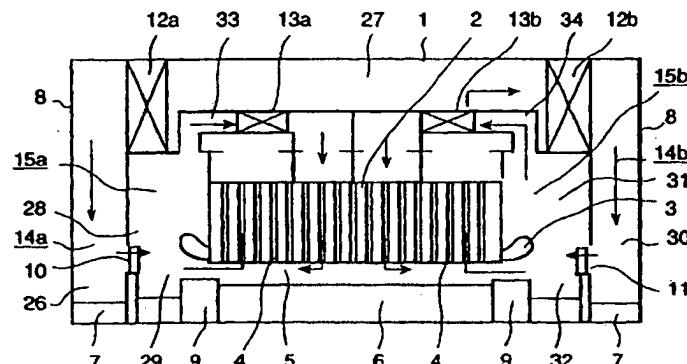
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### (54) Cooling device for an electric rotating machine

(57) In order to provide a rotating machine on which the temperature increase distribution inside the machine can be equalized, the present invention intends not only to install the primary cooler 12 in the primary ventilation passage 14 that extends from the exhaust side of the fans 10 and 11 installed on the rotating axis 7 to the suction side of the fans 10 and 11 via the core but to install the secondary cooler 13 in the

secondary ventilation passage 15 that is branched from the primary ventilation passage 14, thus enabling to further cool part of the cooling medium, which has once been cooled by the primary cooler 12, by means of the secondary cooler, that is, to cool the cooling medium by circulating it through the coolers twice.

FIG. 2



## Description

### BACKGROUND OF THE INVENTION

**[0001]** The present invention relates to a rotating machine that is equipped with coolers in the ventilation passage where a cooling medium flows. In a conventional rotating machine, as described in Japanese application patent laid-open publication Nos. Sho 60-162432 (1985) or Hei 2-70247 (1990) for example, the ventilation passage where a cooling medium flows are toned symmetrically about the rotating axis and an axis perpendicular to the rotating axis, and multiple coolers for cooling the cooling medium are arranged symmetrically about an axis perpendicular to the rotating axis and on top of the rotating machine. Besides, each cooler has the same cooling capacity.

**[0002]** In the above stated conventional rotating machine, however, if heat load increases according as the generating capacity increases, significant temperature difference is caused in the cooling medium depending upon the distance from each cooler and local heat is generated inside the machine, particularly in the so-called air gap, the gap between the stator core and the rotor core. If local heat is generated in the air gap, uneven thermal elongation is caused to the rotor along the axial direction and resultantly the thermal vibration stroke of the rotor is likely to become excessive.

**[0003]** Increasing the heat exchange capacity of the coolers, that is, increasing the size of the coolers may be a means for solving the above problem. However, the absolute value of the temperature increase distribution along the axial direction in the air gap and the absolute value of the local heat can be reduced by this means but the temperature increase distribution along the axial direction in the air gap cannot be equalized simply by increasing the heat exchange capacity of the coolers. Besides, the cooling medium is not utilized efficiently in the above solution because it means that the air gap is cooled although it is already cooled sufficiently and requires no further cooling.

### SUMMARY OF THE INVENTION

**[0004]** The present invention provides a rotating machine where, by equalizing the temperature increase distribution inside the machine, no uneven thermal elongation is caused along the axial direction of the rotor and resultantly the thermal vibration stroke of the rotor will not be excessive.

**[0005]** The basic characteristic of the present invention is that a main cooler and a sub cooler are arranged and configured so that, at least, part of the cooling medium that has been cooled by the main cooler is further cooled by the sub cooler. That is, the cooling medium is cooled twice by the coolers. As a result, it is possible to supply sufficiently cooled cooling medium to the so-called air gap, the gap between the

stator and rotor, along the entire axial direction. As a result, because local heat along the axial direction in the air gap can be restricted and the temperature increase distribution along the axial direction in the air gap can be equalized, no uneven thermal elongation is caused along the axial direction of the rotor and the thermal vibration stroke of the rotor will not be excessive.

**[0006]** The sub cooler is smaller in size than the main cooler, that is, it has smaller cooling capacity. The cooling capacity can be smaller because the sub cooler is to cool part of the cooling medium that has been cooled by the main cooler, and this combination provides more efficient cooling. Because the sub cooler is arranged midway in the branch duct from the fan exhaust side to the stator core outside, that is, in a smaller space than the space where the main cooler is arranged, it must be small in size for ease of installation. For this reason, viewing the rotating machine from the outside, a larger cooler, which is the main cooler, and a smaller cooler, which is the sub cooler, are arranged in series along the axial direction.

### BRIEF DESCRIPTION OF THE DRAWINGS

#### 25 [0007]

Fig. 1 is a sketch drawing of the overall composition of a turbine generator according to the embodiment 1 of the present invention.

30 Fig. 2 is a sectional view II-II of Fig. 1.

Fig. 3 is a sectional view of the internal composition of a turbine generator according to the embodiment 2 of the present invention, showing an improved embodiment of Fig. 2.

35 Fig. 4 is a sectional view of the internal composition of a turbine generator according to the embodiment 3 of the present invention, showing a combined embodiment of Fig. 2 and Fig. 3.

40 Fig. 5 is a sectional view of the internal composition of a turbine generator according to the embodiment 4 of the present invention, showing an improved embodiment of Fig. 2.

Fig. 6 is a sectional view of the internal composition of a turbine generator according to the embodiment 45 5 of the present invention, showing an improved embodiment of Fig. 5.

Fig. 7 is a sectional view of the internal composition of a turbine generator according to the embodiment 6 of the present invention, showing an improved embodiment of Fig. 3.

50 Fig. 8 is a sectional view of a turbine generator according to the embodiment 7 of the present invention.

Fig. 9 is a sectional view of the internal composition of a turbine generator according to the embodiment 55 8 of the present invention.

## DESCRIPTION OF THE INVENTION

[0008] The following describes one embodiment according to the present invention.

[0009] A rotating machine equipped with coolers for cooling the cooling medium charged inside the machine; said coolers comprising primary coolers which are arranged on both ends along the axial direction of the rotating machine and, at least, a secondary cooler which is arranged between said primary coolers and smaller in size than said primary coolers.

[0010] A rotating machine equipped with coolers for cooling the cooling medium charged inside the machine; said coolers comprising multiple primary coolers which are arranged separately along the axial direction of the rotating machine and a secondary cooler which is arranged between said primary coolers and smaller in size than said primary coolers.

[0011] In the above stated rotating machine, the above stated coolers are arranged on top of the rotating machine.

[0012] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers comprising two or more coolers installed in ventilation passage for said cooling medium, wherein, at least, part of the cooling medium cooled by one cooler is further cooled by another cooler.

[0013] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the core and the secondary cooler installed in the secondary passage that is branched from said primary ventilation passage.

[0014] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the core, and the secondary cooler installed at a point of joint in the secondary ventilation passage that is branched from said primary ventilation passage and is joined with other ventilation passage midway at said point of joint.

[0015] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation pas-

sage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the core, the secondary cooler installed in the secondary passage that is branched from said primary ventilation passage, and the tertiary cooler installed at a point of joint in the tertiary ventilation passage that is branched from said primary ventilation passage and is joined with other ventilation passage midway at said point of joint.

[0016] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, and the secondary cooler installed in the secondary ventilation passage extending from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core.

[0017] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, and the secondary cooler installed at a point of joint in the secondary ventilation passage that extends from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core and meets other ventilation passage before reaching the above stated stator core.

[0018] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, the secondary cooler installed in the secondary ventilation passage that extends from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core, and the tertiary cooler installed at a point of joint in the tertiary ventilation passage that extends from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core and meets other ventilation passage before reaching the above stated stator core.

[0019] In the above stated rotating machine, ther-

mat insulation is provided to the ventilation passage extending from the exhaust side of the above stated fan in the primary ventilation passage to the inside of the above stated stator core.

[0020] In the above stated rotating machine, the above stated stator core is equipped along the axial direction with multiple ventilation ducts through which the cooling medium is circulated along the radial direction, and also the ventilation area per unit length of said ventilation duct is varied according to the ventilation direction of the cooling medium.

[0021] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, and the secondary cooler installed in the secondary ventilation passage that extends from before the above stated primary cooler in said primary ventilation passage to the exhaust side of the above stated fan via the end of the above stated stator core.

[0022] A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of the primary fan installed on one end of the above stated rotating axis to the suction side of said primary fan via the core, and the secondary cooler installed in the secondary ventilation passage, which is shorter in length than the above stated primary ventilation passage, extending from the exhaust side of the secondary fan installed on the other end of the above stated rotating axis to the suction side of said secondary fan via the core.

[0023] The embodiments of the present invention will be explained below in reference with the accompanying drawings.

#### [Embodiment 1]

[0024] Fig. 1 shows the overall composition of a turbine generator according to the embodiment 1 and Fig. 2 is a sectional view II-II of Fig. 1. Denotation 1 in the figure represents the stator housing. A cylindrical stator core 2 is provided inside the housing. Multiple continuous slots are formed on the inner surface of the stator core 2, and the stator winding 3 is enclosed inside the slots. Multiple continuous ventilation ducts 4 are provided on the stator core 2 along its radial direction at a nearly equal axial pitch.

[0025] The rotor core 6 is provided inside the stator core 2 leaving the so-called air gap 5. Denotation 7 re-

resents the rotating axis. The rotating axis 7, which is formed into one piece with the rotor core 6, stretches from both ends of the rotor core 6 along the axial direction and is supported by the bearings mounted inside the end bracket 8 covering the both ends of the stator housing 1. Multiple slots are formed on the outer surface of the rotor core 6, and the rotor winding is enclosed inside the slots. Both ends of the rotor winding is fastened by the retaining ring 9.

5 [0026] The fans 10 and 11 are provided on each end of the rotating axis 7. The fans 10 and 11 rotate along with the rotating axis 7 and circulate the charged cooling medium, such as air or hydrogen gas, in the machine. Multiple ventilation passage for smooth circulation 10 of the cooling medium are provided inside the machine symmetrically about the rotating axis 7 and an axis perpendicular to the rotating axis 7. Multiple coolers are arranged midway in the ventilation passage and, 15 at the same time, on top of the generator. Composition 20 of the ventilation passage and arrangement of the coolers depend upon the ventilation system of the cooling medium. According to this embodiment, so-called multi-flow system is employed, where the cooling medium cooled by the coolers circulates in two directions 25 through the ventilation duct 4; along the stator core 2 outside and along the air gap 5.

[0027] For this purpose, the primary ventilation passage 14a is arranged to run inside the machine, comprising the ventilation passage 26 from the stator 30 housing 1 inside to the fan 10 suction side, the ventilation passage 29 from the fan 10 suction side to the air gap 5, the air gap 5, the ventilation duct 4, and the ventilation passage 27 between the stator core 2 outside, including a space opposite to the outside of the end 35 spaces of the stator core 2, and the stator housing 1 inside. The main cooler 12a is installed in the ventilation passage 27 opposite to the fan 10 outside.

[0028] The primary ventilation passage 14b is also arranged to run inside the machine, comprising the ventilation passage 30 from the stator housing 1 inside to the fan 11 suction side, the ventilation passage 32 from the fan 11 suction side to the air gap 5, the air gap 5, the ventilation duct 4, and the ventilation passage between the stator core 2 outside, including a space opposite to 45 the outside of the end spaces of the stator core 2, and the stator housing 1 inside. The main cooler 12b is installed in the ventilation passage 27 opposite to the fan 11 outside.

[0029] The secondary ventilation passage 15a is 50 arranged to run between the fan 10 exhaust side and the air gap 5, comprising the ventilation passage 28 consisting of the end spaces at the fan 10 side of the stator core 2, the ventilation passage 33 from the ventilation passage 28 to the stator core 2 outside, and the ventilation duct 4. The sub cooler 13a is installed midway in the ventilation passage 33. The secondary ventilation passage 15b is arranged to run between the fan 11 exhaust side and the air gap 5, comprising the venti-

lation passage 31 consisting of the end spaces at the fan 11 side of the stator core 2, the ventilation passage 34 from the ventilation passage 31 to the stator core 2 outside, and the ventilation duct 4. The sub cooler 13b is installed midway in the ventilation passage 34.

**[0030]** The primary ventilation passage 14a and the secondary ventilation passage 15a are arranged symmetrically about an axis perpendicular to the rotating axis 7, and so are the primary ventilation passage 14b and the secondary ventilation passage 15b. The main cooler 12 and the sub cooler 13 differ in the cooling capacity and, according to this embodiment, the cooling capacity of the sub cooler 13 is smaller than that of the main cooler 12. Accordingly, the sub cooler 13 is smaller in size than the main cooler 12. The main coolers 12a and 12b are arranged symmetrically about an axis perpendicular to the rotating axis 7, and so are the sub coolers 13a and 13b. Viewing the rotating machine from the outside, the main cooler 12 and the sub cooler 13 are arranged in series along the axial direction on top of the machine, the main coolers 12a and 12b are located on both ends along the axial direction, and the sub coolers 13a and 13b are arranged between the main coolers 12a and 12b.

**[0031]** The cooling water supply pipe 37a for supplying cooling water and the cooling water discharge pipe 38a for discharging cooling water are connected to the main cooler 12a and the sub cooler 13a. The cooling water supply pipe 37b for supplying cooling water and the cooling water discharge pipe 38b for discharging cooling water are connected to the main cooler 12b and the sub cooler 13b.

**[0032]** Although the cooling water supply pipe 37a and the cooling water discharge pipe 38a are connected commonly to the main cooler 12a and the sub cooler 13a and the cooling water supply pipe 37b and the cooling water discharge pipe 38b are connected commonly to the main cooler 12b and the sub cooler 13b according to this embodiment, it is allowable to connect an individual cooling water supply pipe and cooling water discharge pipe to each cooler, or to connect the pipes commonly to the main coolers 12a and 12b and also to the sub coolers 13a and 13b. Denotation 39 in the figure represents the current collector to supply power to the rotor winding.

**[0033]** Hereunder, circulation of the cooling medium is explained. The cooling medium cooled by the main cooler 12a is circulated, as it cools the ventilation passage 26, toward the fan 10 suction side by the rotation of the fan 10, and branched at the fan 10 exhaust side into the ventilation passage 28 and the ventilation passage 29. The cooling medium branched into the ventilation passage 29 is circulated toward the main cooler 12a as it cools the end of the rotor core 6 at the fan 10 side in the ventilation passage 29, the stator core 2 inside and the rotor core 6 outside in the air gap 5, the stator core 2 inside in the ventilation duct 4, and the gap between the stator core 2 and the stator housing 1 in the ventilation passage 27, sequentially.

**[0034]** The cooling medium branched into the ventilation passage 28 is circulated toward the ventilation passage 33 as it cools the end of the stator core 2 at the fan 10 side and the end of the stator winding 3 in the ventilation passage 28. The cooling medium circulated through the ventilation passage 33 is cooled by the sub cooler 13a on its way. The cooling medium cooled by the sub cooler 13a reaches the stator core 2 outside, 5 cools the stator core 2 inside in the ventilation duct 4 and the stator core 2 inside and the rotor core 6 outside in the air gap 5, sequentially, and then meets with the cooling medium from the ventilation passage 29 and is circulated together toward the main cooler 12a.

**[0035]** On the other hand, the cooling medium cooled by the main cooler 12b is circulated, as it cools the ventilation passage 30, toward the fan 11 suction side by the rotation of the fan 11, and branched at the fan 11 exhaust side into the ventilation passage 31 and the ventilation passage 32. The cooling medium branched into the ventilation passage 32 is circulated toward the main cooler 12b as it cools the end of the rotor core 6 at the fan 11 side in the ventilation passage 32, the stator core 2 inside and the rotor core 6 outside 10 in the air gap 5, the stator core 2 inside in the ventilation duct 4, and the gap between the stator core 2 and the stator housing 1 in the ventilation passage 27, sequentially.

**[0036]** The cooling medium branched into the ventilation passage 31 is circulated toward the ventilation passage 34 as it cools the end of the stator core 2 at the fan 11 side and the end of the stator winding 3 in the ventilation passage 31. The cooling medium circulated through the ventilation passage 34 is cooled by the sub cooler 13b on its way. The cooling medium cooled by the sub cooler 13b reaches the stator core 2 outside, 15 cools the stator core 2 inside in the ventilation duct 4 and the stator core 2 inside and the rotor core 6 outside in the air gap 5, sequentially, and then meets the cooling medium from the ventilation passage 32 and is circulated together toward the main cooler 12b.

**[0037]** According to the embodiment 1, because a sub cooler 13, separately from the main cooler 12, is provided midway in the secondary ventilation passage 15 that is branched from the primary ventilation passage 14, the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 29 and 32, can be equalized.

**[0038]** That is to say, in a rotating machine where the cooling medium cooled by the coolers installed on both ends of the machine is circulated by the multi-flow ventilation system, if heat load increases according as the generation capacity increases, temperature of the cooling medium increases to some extent before the cooling medium reaches the center of the air gap. Accordingly, the cooling effect at the said area becomes low and local heat is generated along the axial direction in the air gap.

[0039] According to this embodiment, however, because a sub cooler 13, separately from the main cooler 12, is provided midway in the secondary ventilation passage 15 that is branched from the primary ventilation passage 14 and part of the cooling medium that has been cooled by the main cooler 12 is further cooled by the sub cooler 13, that is, cooled twice through the coolers so that sufficiently cooled cooling medium can be supplied to the center of the air gap, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 29 and 32, can be equalized. As a result, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

[0040] According to the embodiment 1, a small sub cooler 13 having smaller cooling capacity than the main cooler 12 is arranged midway in the secondary ventilation passage 15. The reason for installing a small sub cooler 13 having smaller cooling capacity than the main cooler 12 as above is that, because the sub cooler 13 is used to cool part of the cooling medium that has been cooled by the main cooler 12, its cooling capacity can be as small as the capacity of the cooling medium circulated in the secondary ventilation passage 15 and that higher cooling efficiency can be expected in this system. In addition, sharing the cooling performance by two coolers leads to such advantage that the cooling capacity of the main cooler 12 itself can also be reduced. Because the sub cooler 13 is to be arranged in a smaller space than the space where the main cooler is installed, it must be smaller in size for smooth arrangement.

#### [Embodiment 2]

[0041] Fig. 3 shows the composition of a turbine generator according to the embodiment 2. This embodiment is a modification to the embodiment 1. According to this embodiment, the ventilation passage 33 which is part of the secondary ventilation passage 15a and the ventilation passage 34 which is part of the secondary ventilation passage 15b are joined midway, and a sub cooler 13 is installed at the joint. Viewing the machine from the outside, the main cooler 12 and the sub cooler 13 are arranged in series along the axial direction on top of the machine, the main coolers 12a and 12b are located on both ends along the axial direction, and the sub cooler 13 is arranged between the main coolers 12a and 12b.

[0042] According to the ventilation system of this embodiment configured as above, the cooling medium branched at the fan 10 exhaust side into the ventilation passage 28 and the cooling medium branched at the fan 11 exhaust side into the ventilation passage 32 are joined before the stator core 2 outside and cooled by the sub cooler 13. The cooled cooling medium is circulated from the stator core 2 outside to the air gap 5 through the ventilation duct 4 and branched into the ventilation

passage 29 and 32. The cooling medium branched into the ventilation passage 29 meets the cooling medium circulated through the ventilation passage 29. The cooling medium branched into the ventilation passage 32 meets the cooling medium circulated through the ventilation passage 32.

[0043] According to the embodiment 2, because a sub cooler 13, separately from the main cooler 12, is provided midway in the secondary ventilation passage 15 that is branched from the primary ventilation passage 14 and part of the cooling medium that has been cooled by the main cooler 12 is further cooled by the sub cooler 13, that is, cooled twice through the coolers so that sufficiently cooled cooling medium can be supplied to the center of the air gap, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 29 and 32, can be equalized. As a result, similarly to the previous embodiment, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

#### [Embodiment 3]

[0044] Fig. 4 shows the composition of a turbine generator according to the embodiment 3. This embodiment is a combination of the embodiments 1 and 2. According to this embodiment, the secondary ventilation passage 15 and the tertiary ventilation passage 16 are branched from the primary ventilation passage 14 at the fan exhaust side.

[0045] To be concrete, the secondary ventilation passage 15a is arranged to run between the fan 10 exhaust side and the air gap 5, comprising the ventilation passage 28 consisting of the end spaces at the fan 10 side of the stator core 2, the ventilation passage 33 from the ventilation passage 28 to the stator core 2 outside, and the ventilation duct 4. The sub cooler 13a is installed midway in the ventilation passage 33.

[0046] The secondary ventilation passage 15b is arranged to run between the fan 11 exhaust side and the air gap 5, comprising the ventilation passage 31 consisting of the end spaces at the fan 11 side of the stator core 2, the ventilation passage 34 from the ventilation passage 31 to the stator core 2 outside, and the ventilation duct 4. The sub cooler 13b is installed midway in the ventilation passage 34.

[0047] In addition, the tertiary ventilation passage 16a is arranged to run between the fan 10 exhaust side and the air gap 5, comprising the ventilation passage 28 consisting of the end spaces at the fan 10 side of the stator core 2, the ventilation passage 35 from the ventilation passage 28 to the stator core 2 outside, and the ventilation duct 4; and the tertiary ventilation passage 15b is arranged to run between the fan 11 exhaust side and the air gap 5, comprising the ventilation passage 31 consisting of the end spaces at the fan 11 side of the

stator core 2, the ventilation passage 36 from the ventilation passage 31 to the stator core 2 outside, and the ventilation duct 4.

[0048] The ventilation passage 35 and 36 are joined midway. A sub cooler 13c is installed at the joint. Viewing the machine from the outside, the main cooler 12 and the sub cooler 13 are arranged in series along the axial direction on top of the machine, the main coolers 12a and 12b are located on both ends along the axial direction, and the sub coolers 13a, 13b and 13c are arranged between the main coolers 12a and 12b.

[0049] According to the ventilation system of this embodiment configured as above, the cooling medium branched at the fan 10 exhaust side into the ventilation passage 28 is circulated through the ventilation passage 28, as it cools the end of the stator core 2 at the fan 10 side, and branched at the outside of the passage. One part of the branched cooling medium is circulated through the ventilation passage 33 and cooled by the sub-cooler 13a on its way. The cooling medium cooled by the sub cooler 13a reaches the stator core 2 outside and cools the stator core 2 inside in the ventilation duct 4, and then reaches the air gap 5.

[0050] The other part of the branched cooling medium is circulated through the ventilation passage 35, and then meets the cooling medium circulated from the ventilation passage 36, which is explained later, and is cooled by the sub cooler 13c together. The cooling medium cooled by the sub cooler 13c cools the stator core 2 inside in the ventilation duct 4, and then reaches the air gap 5.

[0051] On the other hand, the cooling medium branched at the fan 11 exhaust side into the ventilation passage 31 is circulated through the ventilation passage 31, as it cools the end of the stator core 2 at the fan 11 side and the end of the stator winding 3, and branched at the outside of the passage. One part of the branched cooling medium is circulated through the ventilation passage 34 and cooled by the sub cooler 13b on its way. The cooling medium cooled by the sub cooler 13b reaches the stator core 2 outside and cools the stator core 2 inside in the ventilation duct 4, and then reaches the air gap 5.

[0052] The other part of the branched cooling medium is circulated through the ventilation passage 36, and then meets the above stated cooling medium circulated from the ventilation passage 35 on its way and is cooled by the sub cooler 13c together. The cooling medium cooled by the sub cooler 13c cools the stator core 2 inside in the ventilation duct 4, and then reaches the air gap 5.

[0053] Besides, the cooling medium circulated from the ventilation passage 33 to the air gap 5 through the ventilation duct 4 is branched at the air gap 5. Then, one part meets the cooling medium circulated from the ventilation passage 29, and the other part meets the cooling medium that has been cooled by the sub cooler 13c and circulated to the air gap 5 through the ventilation

duct 4. The cooling medium circulated from the ventilation passage 34 to the air gap 5 through the ventilation duct 4 is branched at the air gap 5. Then, one part meets the cooling medium circulated from the ventilation passage 32, and the other part meets the cooling medium that has been cooled by the sub cooler 13c and circulated to the air gap 5 through the ventilation duct 4.

[0054] Both the cooling medium that joins the cooling medium circulated from the ventilation passage 33 to the air gap 5 through the ventilation duct 4 and the cooling medium cooled by the sub cooler 13c and circulated to the air gap 5 through the ventilation duct 4 and the cooling medium that joins the cooling medium circulated from the ventilation passage 34 to the air gap 5 through the ventilation duct 4 and the cooling medium cooled by the sub cooler 13c and circulated to the air gap 5 through the ventilation duct 4 are circulated to the ventilation passage 27 through the ventilation duct 4.

[0055] According to the embodiment 3, because a sub cooler 13, separately from the main cooler 12, is provided midway in the secondary ventilation passage 15 that is branched from the primary ventilation passage 14, and another sub cooler 13, separately from the main cooler 12, is provided midway in the tertiary ventilation passage 16 that is branched from the primary ventilation passage 14, and part of the cooling medium that has been cooled by the main cooler 12 is further cooled by the sub cooler 13, that is, cooled twice through the coolers so that sufficiently cooled cooling medium can be supplied to the center of the air gap, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 29 and 32, can be equalized. As a result, similarly to the previous embodiment, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

#### [Embodiment 4]

[0056] Fig. 5 shows the composition of a turbine generator according to the embodiment 4. This embodiment is a modification to the embodiment 1. According to this embodiment, the tertiary ventilation passage 16 is formed so that one part of the cooling medium that has been cooled by the sub cooler 13a, circulated to the air gap 5 through the ventilation duct 4 and then branched there and one part of the cooling medium that has been cooled by the sub cooler 13b, circulated to the air gap 5 through the ventilation duct 4 and then branched there are joined and circulated to the ventilation passage 27 through the ventilation duct 4. The composition viewing from the outside of the machine is similar to that of the embodiment 1.

[0057] According to the embodiment 4, because a sub cooler 13, separately from the main cooler 12, is provided midway in the secondary ventilation passage 15 that is branched from the primary ventilation pas-

sage 14, and part of the cooling medium that has been cooled by the main cooler 12 is further cooled by the sub cooler 13, that is, cooled twice through the coolers so that sufficiently cooled cooling medium can be supplied to the center of the air gap, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 29 and 32, can be equalized. As a result, similarly to the previous embodiment, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

[Embodiment 6]

[0058] Fig. 6 shows the composition of a turbine generator according to the embodiment 5. This embodiment is a modification to the embodiment 4. According to this embodiment, locations and number of units of the main coolers are different in the arrangement. The main cooler 12a is installed in the ventilation passage from the ventilation duct 4 of the primary ventilation passage 14a to the ventilation passage 27, and the main cooler 12b is installed in the ventilation passage from the ventilation duct 4 of the primary ventilation passage 14b to the ventilation passage 27. In addition, the main cooler 13c is newly installed in the ventilation passage from the ventilation duct 4 of the tertiary ventilation passage to the ventilation passage 27. In the same manner as in the embodiment 4, the sub cooler 13a is installed in the ventilation passage 33 and the sub cooler 13b in the ventilation passage 34. Viewing the machine from the outside, the main cooler 12 and the sub cooler 13 are arranged in series along the axial direction on top of the machine, the main coolers 12a, 12b and 12c are located separately along the axial direction, the sub cooler 13a is arranged between the main coolers 12a and 12c, and the sub cooler 13b is arranged between the main coolers 12b and 12c.

[0059] According to the embodiment 5, because a sub cooler 13, separately from the main cooler 12, is provided midway in the secondary ventilation passage 15 that is branched from the primary ventilation passage 14, and part of the cooling medium that has been cooled by the main cooler 12 is further cooled by the sub cooler 13, that is, cooled twice through the coolers so that sufficiently cooled cooling medium can be supplied to the center of the air gap, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 29 and 32, can be equalized. As a result, similarly to the previous embodiment, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

[Embodiment 6]

[0060] Fig. 7 shows the composition of a turbine generator according to the embodiment 6. This embodiment is a modification to the embodiment 2. According to this embodiment, thermal insulation 37 is provided to the ventilation passage 33 and 34. The thermal insulation 37 is made of insulation material such as glass wool, and laid around the inner or outer wall of the ventilation passage:

[0061] The reason for installing the thermal insulation 37 is that, because the ventilation passage 33 and 34 are installed inside the ventilation passage for the cooling medium that is circulated from the air gap 5 to the stator core 2 outside through the ventilation duct, that is, the cooling medium that has been utilized to cool the stator core 2 and become hot, the cooling medium circulated through the ventilation passage 33 and 34 are subjected to heat exchange with the cooling medium circulated from the air gap 5 to the stator core 2 outside through the ventilation duct. If any heat is to be exchanged, the cooling effect of the sub cooler 13 installed at the joint of the ventilation passage 33 and 34 will reduce and, as a result, the cooling effect at the center of the air gap 5 will also reduce.

[0062] For this reason, according to this embodiment, the thermal insulation 37 is laid over the inner or outer wall of the ventilation passage 33 and 34 so as to eliminate possible heat exchange with the cooling medium circulated from the air gap 5 to the stator core 2 outside through the ventilation duct 4, and the effectiveness of the embodiment 2 can be enhanced further.

[0063] In addition, according to the embodiment, axial pitch of the ventilation ducts 4 is varied. In short, in order to equalize the temperature increase distribution, it is important to circulate the cooling medium effectively onto locally heated area. Thus, according to this embodiment, the axial pitch of the ventilation ducts 4, through which the cooling medium is circulated from the air gap 5 to the stator core 2 outside, is made longer and, as a result, the equivalent ventilation area per unit length is reduced so as to control the flow rate of the cooling medium circulated to the stator core 2 outside.

[0064] In addition, by reducing the axial pitch of the ventilation ducts 4 through which the cooling medium is circulated from the stator core 2 outside to the air gap 5 and, as a result, increasing the equivalent ventilation area per unit length, the flow rate of the cooling medium circulated to the center of the air gap 5 is increased.

[0065] According to this embodiment, because more cooling medium can be supplied to the center of the air gap 5 as above and cool it better, the effectiveness in the embodiment 2 can be enhanced further. It is noted that the composition of this embodiment can be applied not only to the embodiment 2 but to others.

## [Embodiment 7]

[0066] Fig. 8 shows the composition of a turbine generator according to the embodiment 7. This embodiment employs so-called single reverse-flow system, where the cooling medium cooled by a cooler is circulated in one direction from the stator core 2 outside to the air gap 5 through the ventilation duct 4.

[0067] Because of this system, the primary ventilation passage 14a is arranged to run inside the machine, comprising the ventilation passage 17 from the fan 10 exhaust side to the stator housing 1 inside, the ventilation passage 25 from the stator core 2 outside to the stator housing 1 inside, the ventilation duct 4, the air gap 5, and the ventilation passage 20 from the air gap 5 to the fan 10 suction side. The main cooler 12a is arranged in the ventilation passage 25 that is opposite to the outside of the end spaces at the fan 10 side of the stator core 2.

[0068] The primary ventilation passage 14b is also arranged to run inside the machine, comprising the ventilation passage 21 from the fan 11 exhaust side to the stator housing 1 inside, the ventilation passage 25 from the stator core 2 outside to the stator housing 1 inside, the ventilation duct 4, the air gap 5, and the ventilation passage 24 from the air gap 5 to the fan 11 suction side. The main cooler 12b is arranged in the ventilation passage 25 that is opposite to the outside of the end spaces at the fan 11 side of the stator core 2.

[0069] The ventilation passage 19, which is the secondary ventilation passage 15a, comprising the end spaces at the fan 10 side of the stator core 2 is arranged between this side of the main cooler 12a in the ventilation passage 17 and the ventilation passage 20. The sub cooler 13a is installed close to the periphery (branched side from the ventilation passage 17) in the secondary ventilation passage 15a. The ventilation passage 23, which is the secondary ventilation passage 15a, comprising the end spaces at the fan 11 side of the stator core 2 is arranged between this side of the main cooler 12b in the ventilation passage 21 and the ventilation passage 24. The sub cooler 13a is installed close to the periphery (branched side from the ventilation passage 21) in the secondary ventilation passage 15a.

[0070] The primary ventilation passage 14a and 14b, and also the secondary ventilation passage 15a and 15b, are symmetrically arranged about an axis perpendicular to the rotating axis 7, respectively. The main cooler 12 and the sub cooler 13 differ in the cooling capacity and, according to this embodiment, the cooling capacity of the sub cooler 13 is smaller than that of the main cooler 12. Accordingly, the sub cooler 13 is smaller in size than the main cooler 12. The main coolers 12a and 12b, and also the sub coolers 13a and 13b, are symmetrically arranged about an axis perpendicular to the rotating axis 7. Viewing the machine from the outside, the main cooler 12 and the sub cooler 13 are arranged in series along the axial direction on top of the

machine, the sub coolers 13a and 13b are located on both ends along the axial direction, and the main coolers 12a and 12b are arranged between the sub coolers 13a and 13b. Description on other composition is omitted because it is similar to that of the previous embodiment.

[0071] Hereunder, circulation of the cooling medium is explained. The cooling medium cooled by the main cooler 12a is circulated toward the fan 10 suction side by the rotation of the fan 10, and cools the gap between the stator core 2 and the stator housing 1 in the ventilation passage 25, the stator core 2 inside in the ventilation duct 4, the stator core 2 inside and the rotor core 6 outside in the air gap 5, and the end of the rotor core 6 at the fan 10 side in the ventilation passage 20, sequentially.

[0072] The cooling medium cooled by the sub cooler 13a is circulated toward the fan 10 suction side through the ventilation passage 19, and cools the end of the stator core 2 at the fan 10 side and the end of the stator winding 3. The two cooling medium flows cooled by each cooler and circulated separately are joined at the fan 10 suction side and circulated from the fan 10 exhaust side toward the main cooler 12a, as they cool the ventilation passage 17, and then branched before the main cooler 12a into the cooling medium toward the main cooler 12a side and the cooling medium toward the sub cooler 13a side.

[0073] On the other hand, the cooling medium cooled by the main cooler 12b is circulated toward the fan 11 suction side by the rotation of the fan 11, and cools the gap between the stator core 2 and the stator housing 1 in the ventilation passage 25, the stator core 2 inside in the ventilation duct 4, the stator core 2 inside and the rotor core 6 outside in the air gap 5, and the end of the rotor core 6 at the fan 11 side in the ventilation passage 24, sequentially.

[0074] The cooling medium cooled by the sub cooler 13b is circulated toward the fan 11 suction side through the ventilation passage 23, and cools the end of the stator core 2 at the fan 11 side and the end of the stator winding 3. The two cooling medium flows cooled by each cooler and circulated separately are joined at the fan 11 suction side and circulated from the fan 11 exhaust side toward the main cooler 12b, as they cool the ventilation passage 21, and then branched before the main cooler 12b into the cooling medium flow toward the main cooler 12b side and the cooling medium flow toward the sub cooler 13b side.

[0075] According to the embodiment 7, because the secondary ventilation passage 15 branched before the main cooler 12 in the primary ventilation passage 14 is arranged to run in the machine and a sub cooler 13 is provided in the branched flow separately from the main cooler 12, the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 20 and 24, can be equalized.

[0076] That is to say, in a rotating machine where

the cooling medium cooled by the coolers installed on both ends of the machine is circulated by the single reverse-flow ventilation system, if heat load increases according as the generation capacity increases, temperature of the cooling medium increases before the cooling medium reaches the suction side of the fan. Accordingly, the cooling effect at the said area becomes low and local heat is generated along the axial direction in the air gap.

[0077] According to this embodiment, however, because the secondary ventilation passage 15 branched before the main cooler 12 in the primary ventilation passage 14 is arranged to run in the machine and a sub cooler 13 is provided in the branched flow separately from the main cooler 12, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 20 and 24, can be equalized. As a result, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

[0078] According to the embodiment 7, a small sub cooler 13 having smaller cooling capacity than the main cooler 12 is arranged midway in the secondary ventilation passage 15. The reason for installing a small sub cooler 13 having smaller cooling capacity than the main cooler 12 as above is that, because the sub cooler 13 is used to cool part of the cooling medium that has been cooled by the main cooler 12, its cooling capacity can be as small as the capacity of the cooling medium circulated in the secondary ventilation passage 15 and that higher cooling efficiency can be expected in this system. In addition, sharing the cooling performance leads to such advantage that the cooling capacity of the main cooler 12 itself can also be reduced. Because the sub cooler 13 is to be arranged in a smaller space than the space where the main cooler is installed, it must be smaller in size for smooth arrangement.

#### [Embodiment 8]

[0079] Fig. 9 shows the composition of a turbine generator according to the embodiment 8. This embodiment, similarly to the embodiment 7, employs so-called single reverse-flow system, where the cooling medium cooled by a cooler is circulated in one direction from the stator core 2 outside to the air gap 5 through the ventilation duct 4.

[0080] Because of this system, the primary ventilation passage 14 is arranged to run inside the machine, comprising the ventilation passage 17 from the fan 10 exhaust side to the stator housing 1 inside, ventilation passage 18 between the stator core 2 outside and the stator housing 1 inside, including the outside of the end spaces of the stator core 2, the ventilation duct 4, the ventilation passage 19 consisting of the end spaces at the fan 10 side of the stator core 2, the air gap 5, and the ventilation passage 20 from the air gap 5 to the fan 10

suction side. The main cooler 12 is arranged in the ventilation passage 18 that is opposite to the outside of the fan 10.

[0081] The primary ventilation passage 15 is arranged to run inside the machine, comprising the ventilation passage 21 from the fan 11 exhaust side to the stator housing 1 inside, ventilation passage 22 between the stator core 2 outside and the stator housing 1 inside, including the outside of the end spaces of the stator core 2, the ventilation duct 4, the ventilation passage 23 consisting of the end spaces at the fan 11 side of the stator core 2, the air gap 5, and the ventilation passage 24 from the air gap 5 to the fan 11 suction side. The sub cooler 13 is arranged in the ventilation passage 22 that is opposite to the outside of the fan 11.

[0082] The primary ventilation passage 14 and the secondary ventilation passage 15 differ in length of the ventilation passage and, according to this embodiment, the length of the secondary ventilation passage is shorter than that of the primary ventilation passage 14. In addition, the main cooler 12 and the sub cooler 13 differ in the cooling capacity and, according to this embodiment, the cooling capacity of the sub cooler 13 is smaller than that of the main cooler 12. Accordingly, the sub cooler 13 is smaller in size than the main cooler 12. Besides, the main cooler 12 and the sub cooler 13 are arranged symmetrically about an axis perpendicular to the rotating axis 7. Viewing the machine from the outside, the main cooler 12 and the sub cooler 13 are arranged in series along the axial direction on top of the machine, the main cooler is located on one end along the axial direction, and the sub cooler 13 is arranged on the other end along the axial direction. Description on other composition is omitted because it is similar to that of the previous embodiment.

[0083] Hereunder, circulation of the cooling medium is explained. The cooling medium cooled by the main cooler 12 is circulated and branched into the ventilation passage 18 and the ventilation passage 19 by the rotation of the fan 10. The cooling medium circulated into the ventilation passage 18 cools the gap between the stator core 2 and the stator housing 1 in the ventilation passage 18, the stator core 2 inside in the ventilation duct 4, the stator core 2 inside and the rotor core 6 outside in the air gap 5, and the end of the rotor core 6 at the fan 10 side in the ventilation passage 20, sequentially, and then it is circulated toward the fan 10 suction side.

[0084] The cooling medium circulated in the ventilation passage 19 cools the end of the stator core 2 at the fan 10 side and the end of the stator winding 3, and then it is circulated toward the fan 10 suction side. The two cooling medium flows are joined at the fan 10 suction side. The joined cooling medium is circulated, as it cools the ventilation passage 17, from the fan 10 exhaust side toward the main cooler 12, and cooled again by the main cooler 12.

[0085] On the other hand, the cooling medium

cooled by the sub cooler 13 is circulated and branched into the ventilation passage 22 and the ventilation passage 23 by the rotation of the fan 11. The cooling medium circulated into the ventilation passage 22 cools the gap between the stator core 2 and the stator housing 1 in the ventilation passage 22, the stator core 2 inside in the ventilation duct 4, the stator core 2 inside and the rotor core 6 outside in the air gap 5, and the end of the rotor core 6 at the fan 11 side in the ventilation passage 24, sequentially, and then it is circulated toward the fan 11 suction side.

**[0086]** The cooling medium circulated in the ventilation passage 23 cools the end of the stator core 2 at the fan 11 side and the end of the stator winding 3, and then it is circulated toward the fan 11 suction side. The two cooling medium flows are joined at the fan 11 suction side. The joined cooling medium is circulated, as it cools the ventilation passage 21, from the fan 11 exhaust side toward the sub cooler 13, and cooled again by the sub cooler 13.

**[0087]** According to the embodiment 8, because the secondary ventilation passage 15 with shorter passage length than the primary ventilation passage 14 is arranged to run in the machine and a sub cooler 13 is provided in the ventilation passage separately from the main cooler 12, the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 20 and 24, can be equalized.

**[0088]** That is to say, in a rotating machine where the cooling medium cooled by the cooler installed on either end of the machine is circulated by the single reverse-flow ventilation system, if heat load increases according as the generation capacity increases, temperature of the cooling medium increases before the cooling medium reaches the fan located apart from the cooler (the other end inside of the machine). Accordingly, the cooling effect at the said area becomes low and local heat is generated along the axial direction in the air gap.

**[0089]** According to this embodiment, however, because the secondary ventilation passage 15 with shorter passage length than the primary ventilation passage 14 is arranged to run in the machine and a sub cooler 13 is provided in the ventilation passage separately from the main cooler 12, generation of local heat can be restricted and the temperature increase distribution along the axial direction in the air gap 5, including the ventilation passage 20 and 24, can be equalized. As a result, the thermal vibration stroke of the rotor caused by uneven thermal elongation of the rotor along the axial direction can be controlled.

**[0090]** According to the embodiment 8, a small sub cooler 13 having smaller cooling capacity than the main cooler 12 is arranged midway in the secondary ventilation passage 15. The reason for installing a small sub cooler 13 having smaller cooling capacity than the main cooler 12 as above is that, because the sub cooler 13 is used to cool the cooling medium to be circulated in the

secondary ventilation passage which is shorter in length than the primary ventilation passage 14 where the main cooler 12 is installed, its cooling capacity can be as small as the capacity of the cooling medium circulated in the secondary ventilation passage 15 and that higher cooling efficiency can be expected in this system.

### Claims

1. A rotating machine equipped with coolers for cooling the cooling medium charged inside the machine; said coolers comprising primary coolers which are arranged on both ends along the axial direction of the rotating machine and, at least, a secondary cooler which is arranged between said primary coolers and smaller in size than said primary coolers.
2. A rotating machine equipped with coolers for cooling the cooling medium charged inside the machine; said coolers comprising multiple primary coolers which are arranged separately along the axial direction of the rotating machine and a secondary cooler which is arranged between said primary coolers and smaller in size than said primary coolers.
3. A rotating machine according to Claim 1 or 2 wherein the above stated coolers are arranged on top of the rotating machine.
4. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers comprising two or more coolers installed in ventilation passage for said cooling medium, wherein, at least, part of the cooling medium cooled by one cooler is further cooled by another cooler.
5. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the core and the secondary cooler installed in the secondary passage that is branched from said primary ventilation passage.
6. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising

ing the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the core, and the secondary cooler installed at a point of joint in the secondary ventilation passage that is branched from said primary ventilation passage and is joined with other ventilation passage midway at said point of joint. 5

7. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the core, the secondary cooler installed in the secondary ventilation passage that is branched from said primary ventilation passage, and the tertiary cooler installed at a point of joint in the tertiary ventilation passage that is branched from said primary ventilation passage and is joined with other ventilation passage midway at said point of joint. 10

8. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, and the secondary cooler installed in the secondary ventilation passage extending from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core. 15

9. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, and the secondary cooler installed at a point of joint in the secondary ventilation passage that extends from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core. 20

10. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, the secondary cooler installed in the secondary ventilation passage that extends from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core, and the tertiary cooler installed at a point of joint in the tertiary ventilation passage that extends from the exhaust side of the above stated fan in said primary ventilation passage to the inside of the above stated stator core via the above stated stator core and meets other ventilation passage before reaching the above stated stator core. 25

11. A rotating machine according to either of Claims 8 to 10, wherein thermal insulation is provided to the ventilation passage extending from the exhaust side of the above stated fan in the primary ventilation passage to the inside of the above stated stator core. 30

12. A rotating machine according to either of Claim 8 to 10, wherein the above stated stator core is equipped along the axial direction with multiple ventilation ducts through which the cooling medium is circulated along the radial direction, and also the ventilation area per unit length of said ventilation duct is varied according to the ventilation direction of the cooling medium. 35

13. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of a fan installed on the above stated rotating axis to the suction side of said fan via the stator core, and the secondary cooler installed in the secondary ventilation passage that extends from before the above stated primary cooler in said primary ventilation passage to the exhaust side of the above stated fan via the end of the above stated stator core. 40

14. A rotating machine equipped with coolers for cooling the cooling medium which is circulated inside the machine by the rotation of a fan installed on the rotating axis; said coolers being installed in ventilation

tion passage for said cooling medium and comprising the primary cooler installed in the primary ventilation passage extending from the exhaust side of the primary fan installed on one end of the above stated rotating axis to the suction side of said primary fan via the core, and the secondary cooler installed in the secondary ventilation passage, which is shorter in length than the above stated primary ventilation passage, extending from the exhaust side of the secondary fan installed on the other end of the above stated rotating axis to the suction side of said secondary fan via the core.

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FIG. 1

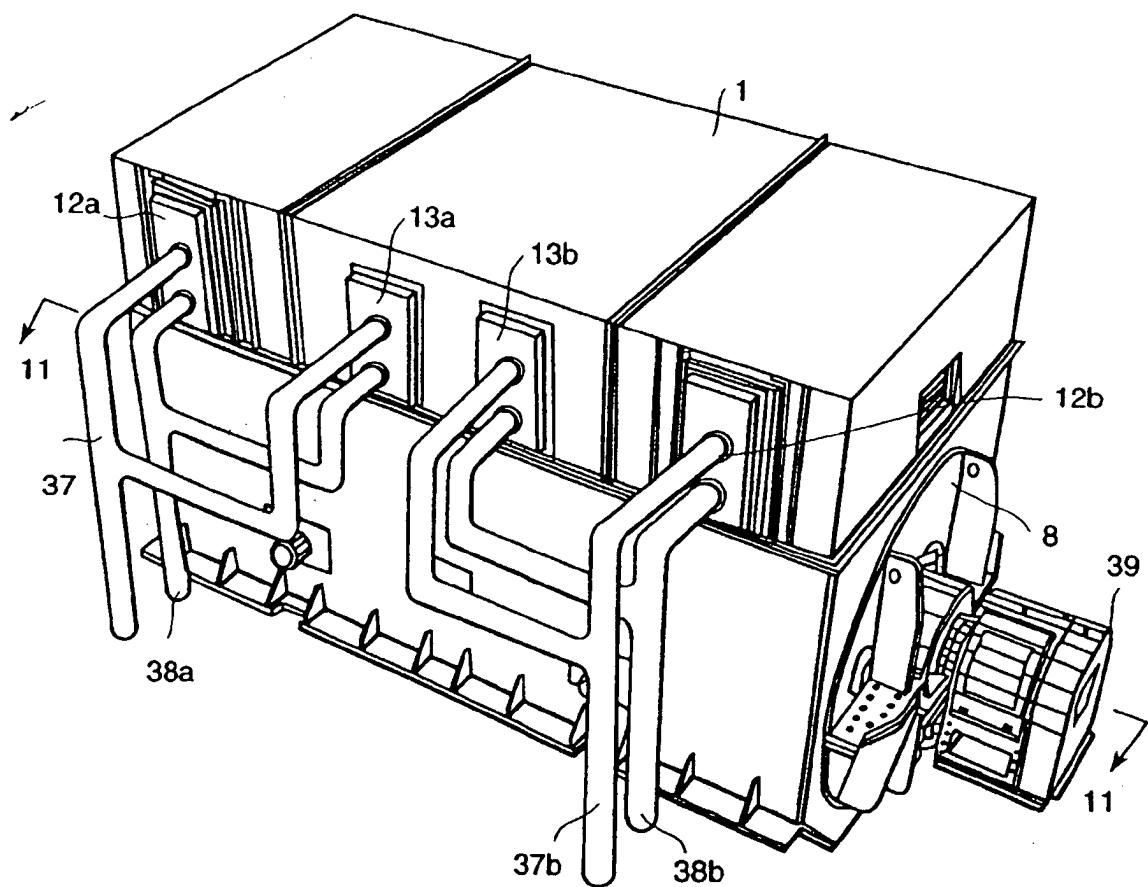


FIG. 2

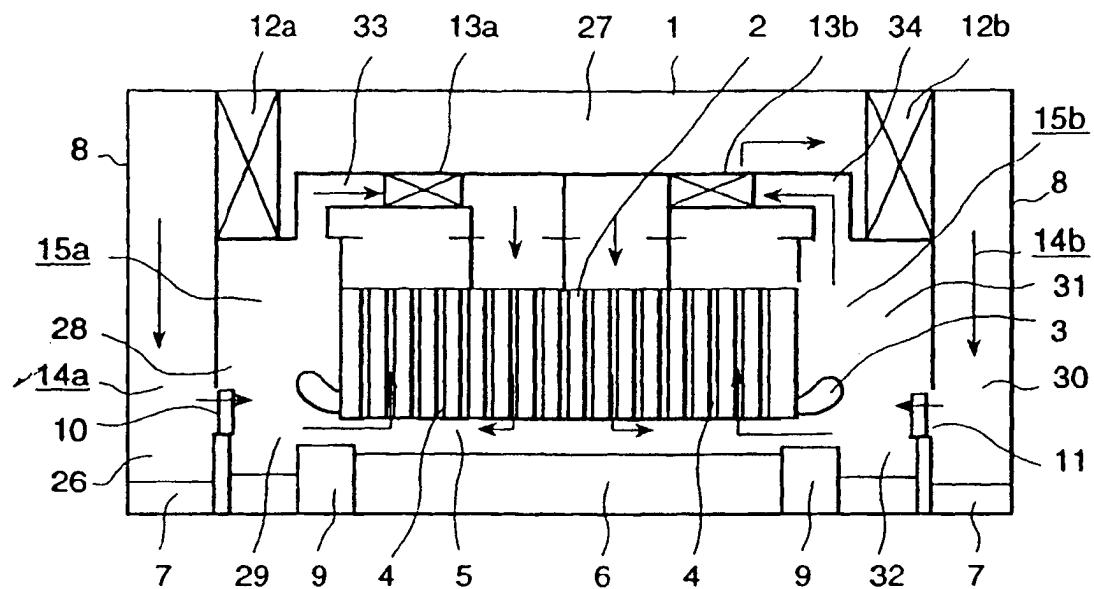


FIG. 3

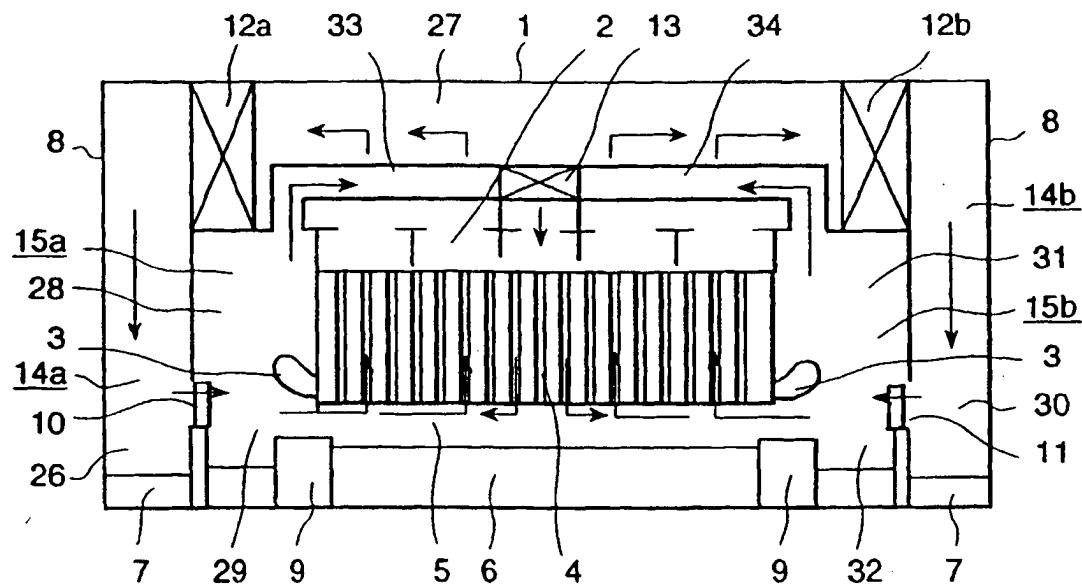


FIG. 4

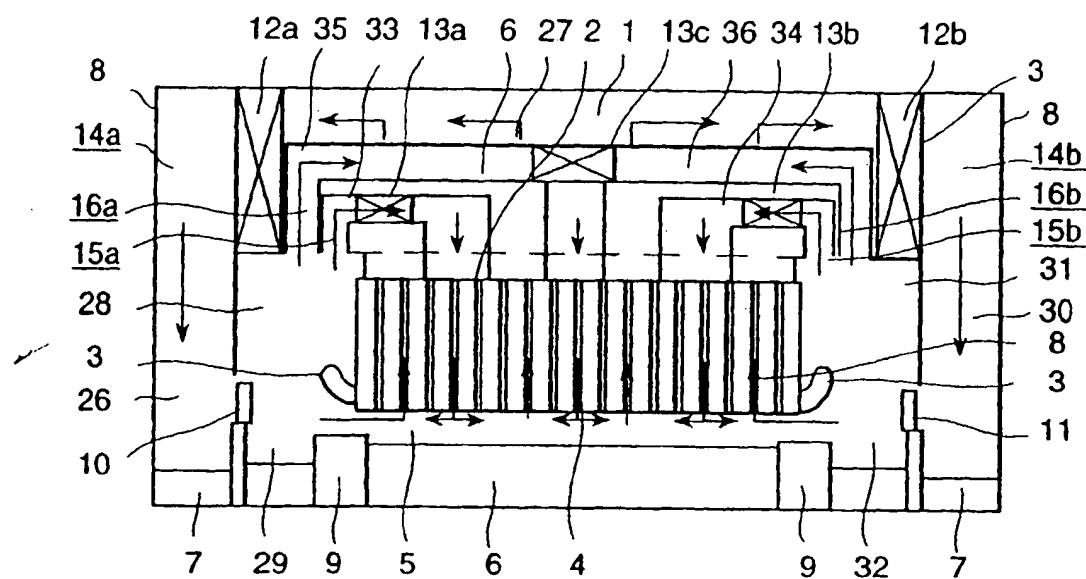
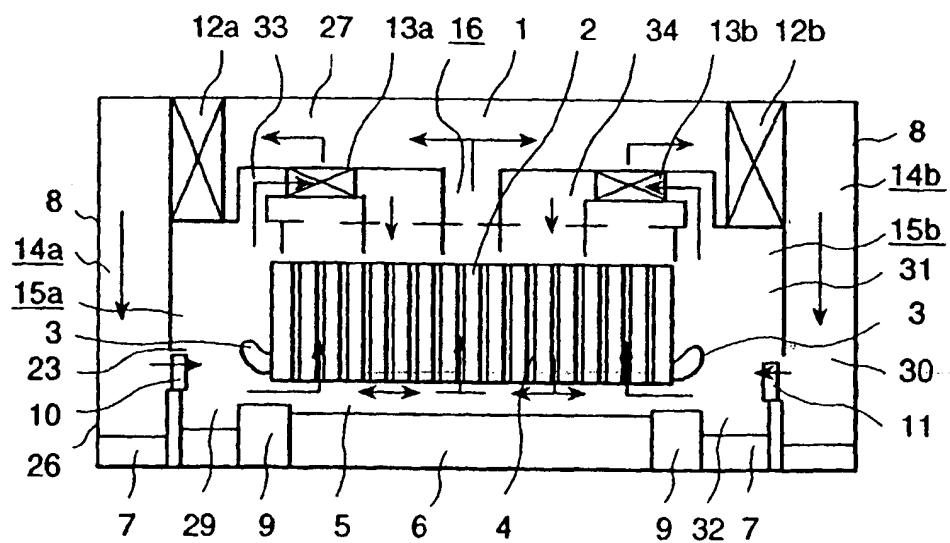
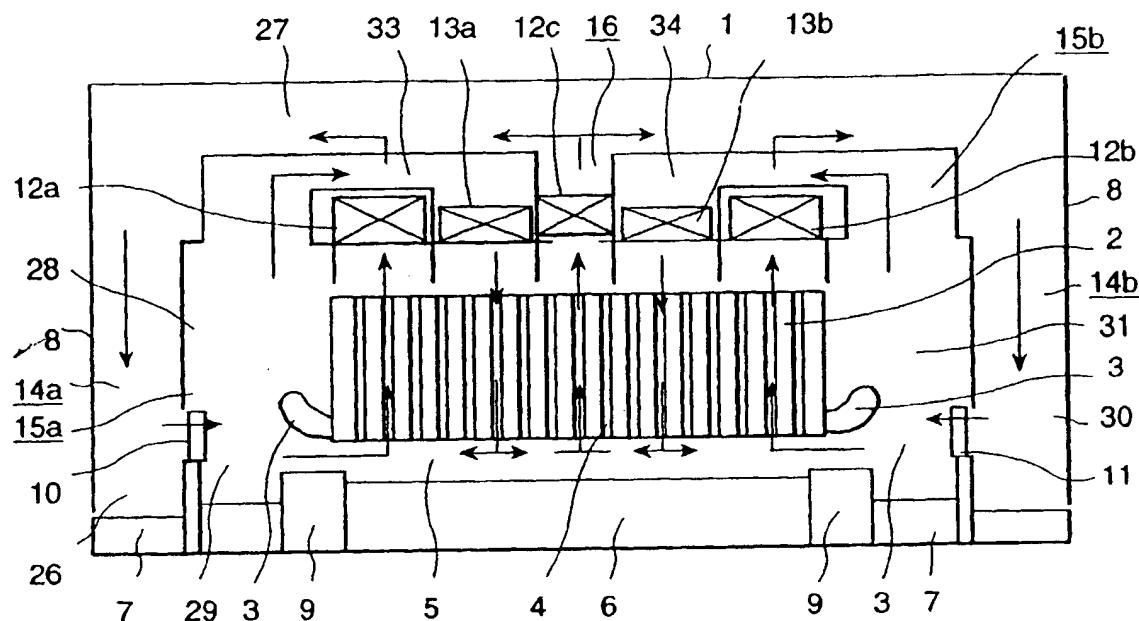


FIG. 5



*FIG. 6*



*FIG. 7*

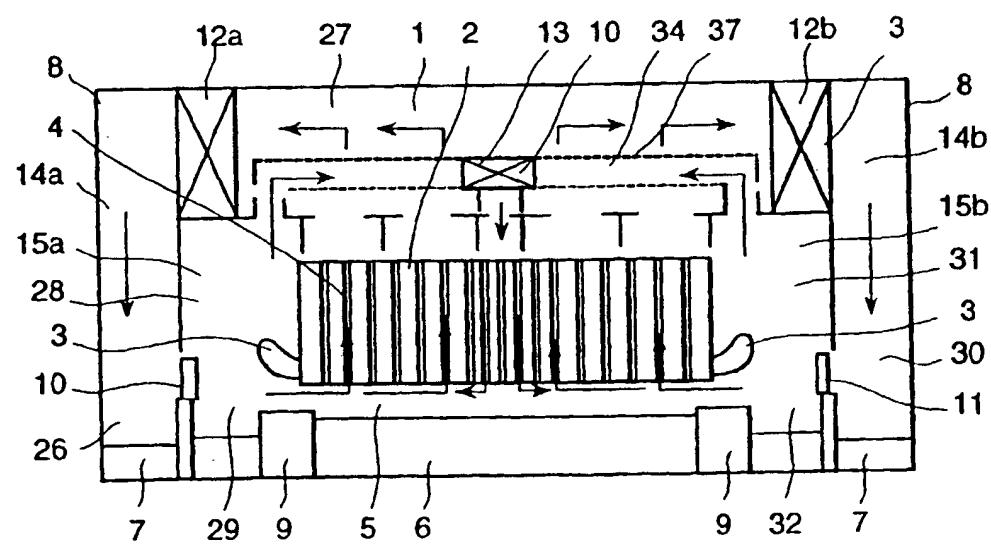


FIG. 8

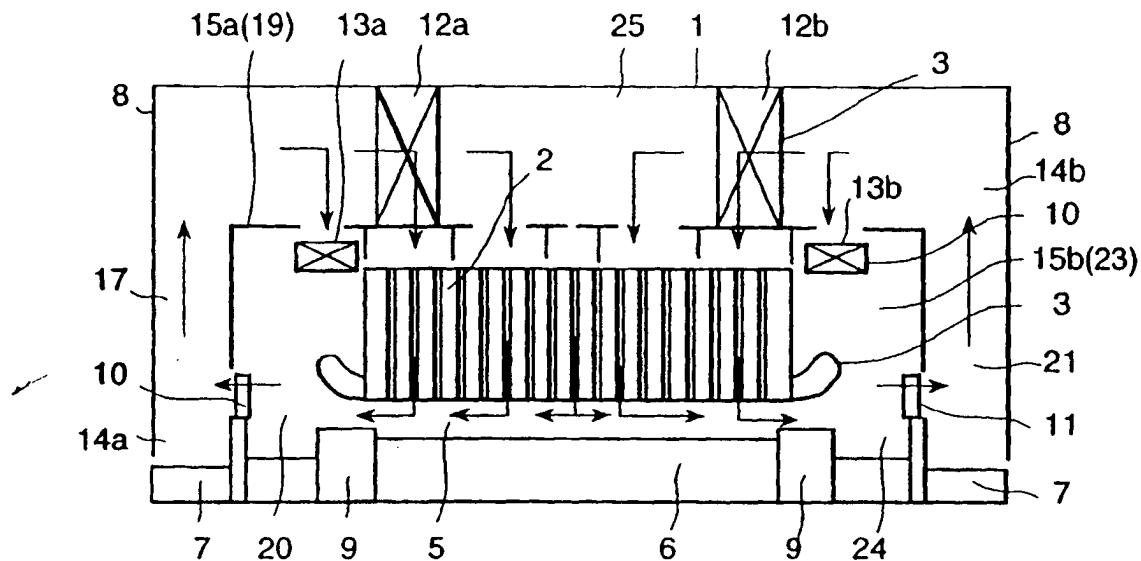
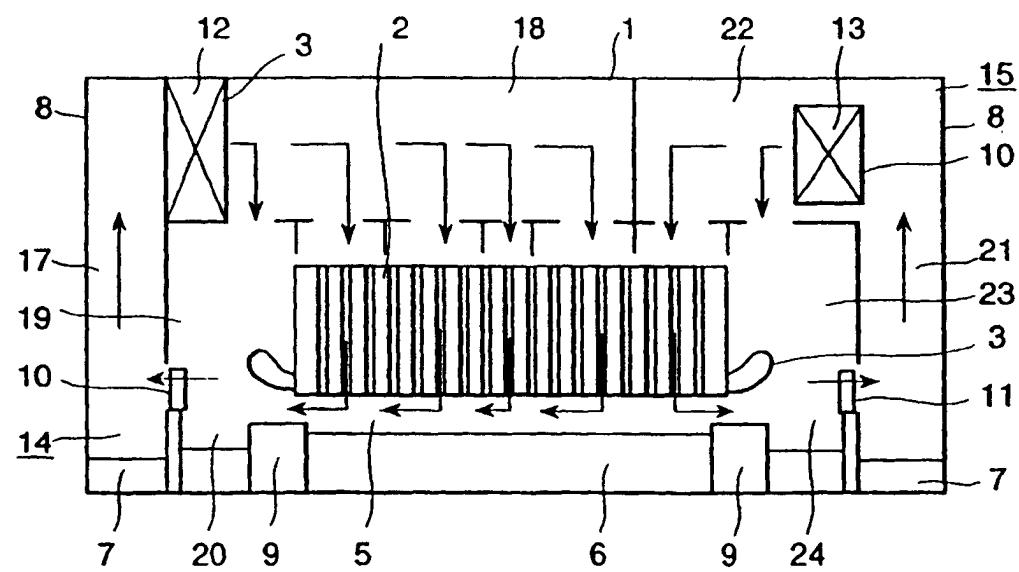


FIG. 9



(19)



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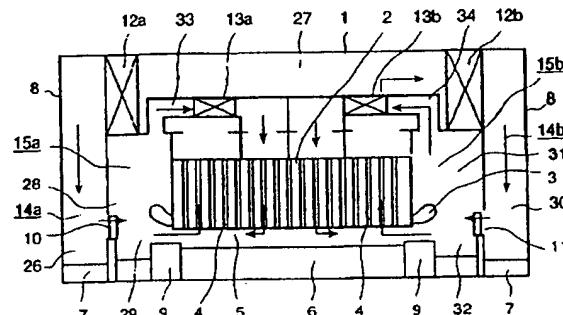
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### (54) Cooling device for an electric rotating machine

(57) In order to provide a rotating machine on which the temperature increase distribution inside the machine can be equalized, the present invention intends not only to install the primary cooler 12 in the primary ventilation passage 14 that extends from the exhaust side of the fans 10 and 11 installed on the rotating axis 7 to the suction side of the fans 10 and 11 via the core

but to install the secondary cooler 13 in the secondary ventilation passage 15 that is branched from the primary ventilation passage 14, thus enabling to further cool part of the cooling medium, which has once been cooled by the primary cooler 12, by means of the secondary cooler, that is, to cool the cooling medium by circulating it through the coolers twice.

FIG. 2





DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)						
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim							
A	US 4 182 966 A (MISHRA ET AL.) 8 January 1980 (1980-01-08) * abstract *	1,2,13, 14	H02K9/04 H02K9/18						
X	* column 3, line 47 - column 4, line 6 * * column 4, line 46-64 * * column 5, line 53 - column 11; figures 1-3 *	4-9,12							
X	US 3 237 032 A (V. J. VICKERS ET AL.) 22 February 1966 (1966-02-22)	1-4							
A	* column 1, line 44 - column 3, line 51; figures 1-5 *	5-10,13, 14							
A	US 4 876 470 A (GELLER) 24 October 1989 (1989-10-24) * abstract * * column 3, line 16-59 * * column 5, line 31 - column 6, line 26; figures 1,2,4-6 *	1-10,13, 14							
A	US 1 672 680 A (E. H. FREIBURGHOUSE) 5 June 1928 (1928-06-05) * page 1, line 4-28 * * page 1, line 102 - page 2, line 33; figures 1-5 *	1-10,13, 14	TECHNICAL FIELDS SEARCHED (Int.Cl.7) H02K						
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 60 (E-102), 17 April 1982 (1982-04-17) -& JP 57 003551 A (HITACHI LTD), 9 January 1982 (1982-01-09) * abstract; figure 3 *	1,2, 4-10,13, 14							
<p>The present search report has been drawn up for all claims</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 33%;">Place of search</td> <td style="width: 33%;">Date of completion of the search</td> <td style="width: 34%;">Examiner</td> </tr> <tr> <td>BERLIN</td> <td>15 November 2001</td> <td>Beitner, M</td> </tr> </table> <p>CATEGORY OF CITED DOCUMENTS</p> <p>X : particularly relevant if taken alone  Y : particularly relevant if combined with another document of the same category  A : technological background  O : non-written disclosure  P : Intermediate document</p> <p>T : theory or principle underlying the invention  E : earlier patent document, but published on, or after the filing date  D : document cited in the application  L : document cited for other reasons  A : member of the same patent family, corresponding document</p>				Place of search	Date of completion of the search	Examiner	BERLIN	15 November 2001	Beitner, M
Place of search	Date of completion of the search	Examiner							
BERLIN	15 November 2001	Beitner, M							

ANNEX TO THE EUROPEAN SEARCH REPORT  
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